Claims

What is claimed is:

1. A method for determining integrity of a cable under test utilizing a cable testing system that uses frequency domain reflectometry (FDR), said method comprising the steps of:

(1) coupling the FDR cable testing system to a connecting end of the cable under test;

(2) transmitting at least one input signal from the FDR cable testing system to the cable under test;

(3) receiving a reflected input signal from the cable under test;

(4) mixing the at least one input signal and the reflected input signal to generate a DC signal; and

(5) processing the DC signal to thereby obtain data regarding integrity of the cable under test.

2. The method as defined in claim 1 wherein the step of obtaining data regarding integrity of the cable under test further comprises the step of determining impedance of the cable under test at a point of termination thereof.

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3. The method as defined in claim 2 wherein the method further comprises the steps of:

(1) determining if the cable under test has a short circuit at the point of termination, wherein a short circuit is indicated by a small impedance value at the point of termination; and

(2) determining if the cable under test has an open circuit at the point of termination, wherein an open circuit is indicated by a large impedance value at the point of termination.

4. The method as defined in claim 3 wherein the method further comprises the step of determining a length of the cable under test from the connecting end to the point of termination.

5. The method as defined in claim 4 wherein the method of determining a length of the cable under test further comprises the step of mixing the at least one input signal and the reflected input signal to thereby generate a mixed signal having at least three components.

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6. The method as defined in claim 5 wherein the method further comprises the steps of:

(1) generating the sum of the at least one input signal and the reflected input signal;

(2) generating the difference of the at least one input signal and the reflected input signal; and

(3) generating the at least one input signal, wherein the three components form the mixed signal.

7. The method as defined in claim 6 wherein the method further comprises the step of filtering out high frequency components from the mixed signal.

8. The method as defined in claim 7 wherein the method further comprises the steps of:

(1) dropping the sum of the at least one input signal and the reflected input signal;

(2) dropping the at least one input signal; and

(3) converting the difference of the at least one input signal and the reflected input signal which is an analog direct current (DC) voltage signal to a digital signal.

9. The method as defined in claim 8 wherein the method further comprises the steps of:

(1) generating a plurality of input signals, wherein the plurality of input signals are utilized to generate a plurality of digital signals;

(2) storing the plurality of digital signals in an array, wherein a frequency of each of the plurality of input signals is associated with a corresponding digital signal that is generated thereby;

(3) performing a Fast Fourier Transform (FFT) on each of the plurality of digital signals to thereby generate a plurality of Fourier signals, one for each of the plurality of digital signals, and wherein each of the plurality of Fourier signals has a given magnitude;

(4) determining which of the plurality of Fourier signals has a greatest magnitude; and

(5) translating the Fourier signal having the greatest magnitude to a distance along the cable under test relative to the connecting end, thereby determining a length of the cable under test to the point of termination.

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10. The method as defined in claim 9 wherein the method further comprises the step of calculating the length of the cable under test utilizing the equation

$$L = \frac{uN}{2 f_{BW}},$$

wherein L is the length of the cable under test to the point of termination, wherein u is the velocity of propagation of the input signal in the cable under test, wherein N is the number of cycles in the digital signal, and wherein f_{BW} is the bandwidth in Hertz of a sampling range.

11. The method as defined in claim 10 wherein the step of determining impedance of the cable under test at the point of termination further comprises the step of solving the equations $Z_{in} = Z_0 \frac{(p+1)}{(p-1)}$ and $Z_L = \frac{Z_0(Z_{in} - jZ_0 \tan \beta l)}{(Z_0 - jZ_{in} \tan \beta l)}$,

to thereby determine an input impedance of the cable under test, wherein Z_{in} is the input impedance of the cable under test, p is the complex reflection coefficient of the cable

under test, Z_0 is the impedance at the point of termination of the cable under test, l is the length of the cable under test, and Z_L is the impedance of the termination of the cable under test.

12. The method as defined in claim 11 wherein the step of transmitting the at least one input signal from the FDR cable testing system to the cable under test further comprises the steps of:

(1) providing a personal computer, wherein the personal computer generates a command signal containing a predetermined frequency for a sine wave; and

(2) providing a voltage controlled oscillator (VCO), wherein the VCO receives the command signal and generates the sine wave of the predetermined frequency value to thereby produce the input signal.

13. The method as defined in claim 12 wherein the method further comprises the steps of:

(1) providing a power divider, wherein the power divider splits the input signal;

(2) providing a mixer, wherein the mixer receives the input signal that is split by the power divider; and

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(3) providing the cable under test, wherein the cable under test also receives the input signal that is split by the power divider.

14. The method as defined in claim 13 wherein the method further comprises the steps of:

(1) transmitting the reflected input signal from the point of termination of the cable under test to a directional coupler;

(2) transmitting the reflected input signal from the directional coupler to an amplifier; and

(3) amplifying the reflected input signal to thereby have a magnitude that is approximately the same as the input signal that was transmitted to the mixer.

15. The method as defined in claim 14 wherein the method further comprises the steps of:

(1) mixing the input signal received from the power divider and the reflected and amplified input signal received from the amplifier; and

(2) generating the mixed signal as defined in claim 6.

16. The method as defined in claim 15 wherein the method further comprises the steps of:

(1) filtering high frequency components from the mixed signal;

(2) digitizing the analog mixed signal; and

(3) transmitting the digitized signal to the personal computer for storage in the array of claim 9.

17. The method as defined in claim 16 wherein the method further comprises the steps of:

(1) generating the command signal that contains the first frequency for the VCO to generate;

(2) receiving the digital signal from the A/D converter;

(3) adding a stepped input frequency to a previous frequency transmitted to the VCO to generate a new frequency for the VCO to generate;

(4) transmitting the new frequency to the VCO in a new command signal; and

(5) repeating steps (2) through (4) until the new frequency is equal to or greater than a predetermined stop frequency.

18. The method as defined in claim 17 wherein the method further comprises the step of utilizing the personal computer to analyze the array after the stop frequency is reached in order to determine the length of the cable under test, and an impedance of the cable under test, to thereby determine if the cable under test ends in a short circuit or an open circuit.

19. A cable testing system that utilizes principles of frequency domain reflectometry (FDR) to thereby determine characteristics of a cable under test (CUT), said cable testing system comprising:

a voltage controlled oscillator (VCO) for generating an input signal;

a power divider for receiving the input signal from the VCO and dividing the input signal;

a mixer for receiving the input signal from the power divider;

wherein the CUT also receives the input signal from the power divider, and generates a reflected input signal, and wherein the mixer receives the input signal and the reflected input signal to thereby generate a mixed signal having at least two components;

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an analog to digital (A/D) converter for receiving the mixed signal and filtering out high frequency components therefrom, and for generating a digital signal, wherein the digital signal contains a signal that is dependent upon a frequency of the input signal, a length of the CUT, and of a point of termination of the CUT; and

a processor for utilizing the digital signal to thereby determine characteristics of the cable under test.

20. The cable testing system as defined in claim 19 wherein the cable testing system further comprises a computer, wherein the computer controls the VCO and performs calculations to thereby determine the characteristics of the cable under test.

21. The cable testing system as defined in claim 20 wherein the cable testing system further comprises:

a directional coupler for receiving the reflected input signal from the CUT; and

an amplifier for receiving the reflected input signal from the directional coupler and amplifying the reflected input signal, wherein the amplifier transmits the reflected input signal to the mixer.

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22. A method for determining characteristics of a cable under test utilizing a cable testing system that uses principles of frequency domain reflectometry (FDR), said method comprising the steps of:

(1) providing a signal generator for generating a sine wave, a power divider coupled to signal generator at an input, and to a mixer and the cable under test at two outputs, wherein the mixer is also coupled at another input to the cable under test for receiving a reflected sine wave therefrom, and at an output to an input of an analog to digital (A/D) converter, wherein the A/D converter is coupled at an output to a processor;

(2) transmitting a sine wave from the signal generator to the cable under test and to the mixer via the power divider;

(3) receiving a reflected sine wave from the cable under test at the mixer;

(4) mixing the sine wave and the reflected sine wave to generate a DC signal from the mixer;

(5) processing the DC signal to thereby obtain data regarding impedance and length of the cable under test;

(6) changing a frequency of the sine wave;

(7) performing steps (2) through (6) a predetermined number of times to thereby generated a plurality of DC signals; and

(8) determining impedance and length of the cable under test utilizing the plurality of DC signals.

23. The method as defined in claim 22 wherein the method further comprises the step of mixing the sine wave and the reflected sine wave to thereby generate a mixed signal having at least two components.

24. The method as defined in claim 23 wherein the method further comprises the steps of:

(1) generating the sum of the sine wave and the reflected sine wave;

(2) generating the difference of the sine wave and the reflected sine wave; and

(3) generating the sine wave, wherein the sum, different and original sine wave for three components of the mixed signal.

25. The method as defined in claim 24 wherein the method further comprises the step of filtering out high frequency components from the mixed signal.

26. The method as defined in claim 25 wherein the method further comprises the steps of:

(1) dropping the sum of the sine wave and the reflected sine wave;

(2) dropping the at least one input signal; and

(3) converting the difference of the sine wave and the reflected sine wave, which is an analog direct current (DC) voltage signal, to a digital signal, wherein a plurality of digital signals are generated by the plurality of sine waves.

27. The method as defined in claim 26 wherein the step of determining impedance and length of the cable under test further comprises the step of determining impedance of the cable under test at a point of termination thereof.

28. The method as defined in claim 27 wherein the method further comprises the steps of:

(1) determining if the cable under test has a short circuit at the point of termination, wherein a short circuit is indicated by a small impedance value at the point of termination; and

(2) determining if the cable under test has an open circuit at the point of termination, wherein an open circuit is indicated by a large impedance value at the point of termination.

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29. The method as defined in claim 28 wherein the method further comprises the steps of:

(1) storing the plurality of digital signals in an array, wherein a frequency of each of the plurality of sine waves is associated with a corresponding digital signal that is generated thereby;

(2) performing a Fast Fourier Transform (FFT) on each of the plurality of digital signals to thereby generate a plurality of Fourier signals, one for each of the plurality of digital signals, and wherein each of the plurality of Fourier signals has a given magnitude;

(3) determining which of the plurality of Fourier signals has a greatest magnitude; and

(4) translating the Fourier signal having the greatest magnitude to a distance along the cable under test, thereby determining a length of the cable under test to the point of termination.

30. The method as defined in claim 29 wherein the method further comprises the step of calculating the length of the cable under test utilizing the equation

$$L = \frac{uN}{2 f_{BW}},$$

wherein L is the length of the cable under test to the point of termination, wherein u is the velocity of propagation of the sine wave in the cable under test, wherein N is the number of cycles of the digital signal as a function of frequency, and wherein f_{BW} is the bandwidth in Hertz of a sampling range.

31. The method as defined in claim 30 wherein the step of determining impedance of the cable under test at the point of termination further comprises the step of solving the equations $Z_{in} = Z_0 \frac{(p+1)}{(p-1)}$ and $Z_L = \frac{Z_0(Z_{in} - jZ_0 \tan\beta l)}{(Z_0 - jZ_{in} \tan\beta l)}$

to thereby determine an input impedance of the cable under test, wherein Z_{in} is the input impedance of the cable under test, p is the complex reflection coefficient of the cable under test, Z_0 is the impedance at the point of termination of the cable under test, l is the length of the cable under test, and Z_L is the impedance of the termination of the cable under test.

32. The method as defined in claim 31 wherein the method further comprises the steps of:

(1) providing a personal computer, wherein the personal computer generates a command signal containing a predetermined frequency for the sine wave; and

(2) providing a voltage controlled oscillator (VCO) as the signal generator, wherein the VCO receives the command signal and generates the sine wave of the predetermined frequency value.

33. The method as defined in claim 32 wherein the method further comprises the steps of:

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(1) transmitting the reflected sine wave from the point of termination of the cable under test to a directional coupler;

(2) transmitting the reflected sine wave from the directional coupler to an amplifier; and

(3) amplifying the reflected sine wave to thereby have a magnitude that is approximately equal to that of the sine wave that was transmitted to the mixer.

34. The method as defined in claim 33 wherein the method further comprises the step of utilizing the personal computer to analyze the array after no more sine waves are being generated in order to determine the length of the cable under test, and an impedance of the cable under test, to thereby determine if the cable under test ends in a short circuit or an open circuit.